CLAIMS:

1. A method for monitoring patient cardiac signals and the contraction and expansion of the heart chambers during heart cycles and processing such signals within an implantable medical device (IMD) to provide data related to the mechanical performance of the heart comprising:

implanting a magnetic field strength sensor at a sensor site in or on a first heart chamber;

implanting a magnetic field generator that generates a magnetic field at a magnet site in or on a second heart chamber displaced from the sensor site at a distance that fluctuates with the contraction and expansion of at least the first heart chamber; and

operating the magnetic field strength sensor during at least a portion of the heart cycle to develop a sensor output signal having a magnitude and rate of change in magnitude dependent upon the magnetic field strength of the magnetic field directly related to the distance between the magnet and sensor sites that fluctuates with the contraction and expansion of one or both of the first heart chamber and second heart chamber, whereby the output signal magnitude or rate of change of magnitude is representative of the mechanical performance of the heart chamber.

2. The method of Claim 1, wherein the sensor site is within the right ventricle and the magnet site is alongside the left ventricle.

3. The method of Claim 2, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

4. The method of Claim 3, wherein the magnetic field generator is a permanent magnet.

5. The method of Claim 1, wherein the sensor site is within the right ventricle and the magnet site is alongside the left ventricle within a coronary vein.

6. The method of Claim 5, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

7. The method of Claim 6, wherein the magnetic field generator is a permanent magnet.

8. The method of Claim 1, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

9. The method of Claim 2, wherein the magnetic field generator is a permanent magnet.

10. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering a pacing pulse to the first heart chamber to elicit a contraction of the first heart chamber;

conducting the operating step after delivery of the pacing pulse; and

adjusting a parameter of the delivered pacing pulse as a function of the determined mechanical performance of the first heart chamber during a heart cycle following delivery of a pacing pulse.

11. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering a pacing pulse to the first heart chamber to elicit a contraction of the first heart chamber;

conducting the operating step after delivery of the pacing pulse; and

adjusting the pacing energy of succeeding delivered pacing pulses to a pulse energy sufficient to elicit the contraction of the first heart chamber upon delivery of a pacing pulse if the magnetic field strength sensor fails to develop a sensor output signal having a magnitude signifying contraction of the first heart chamber in response to the delivered pacing pulse.

12. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering pacing pulses to the first heart chamber at a predetermined pacing rate to elicit contractions of the first heart chamber;

conducting the operating step after delivery of the pacing pulse; and

adjusting the pacing rate of succeeding delivered pacing pulses to a pacing rate sufficient to elicit the contraction of the first heart chamber upon delivery of each pacing pulse.

13. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering pacing pulses to the first heart chamber at a predetermined pacing rate to elicit contractions of the first heart chamber;

conducting the operating step after delivery of the pacing pulse;

determining contractility of the first heart chamber as a function of the magnitude or rate of change of magnitude of the sensor output signal; and

adjusting the pacing rate of succeeding delivered pacing pulses to a pacing rate that is proportional to the measured contractility sufficient to maximize the contractility of the first heart chamber upon delivery of each pacing pulse.

14. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system having a sense amplifier, and further comprising:

operating the sense amplifier to sense electrical activity of the first heart chamber accompanying a contraction of the first heart chamber and to provide a sense event signal;

conducting the operating step after delivery of the pacing pulse; and

increasing the sensitivity of the sense amplifier or providing a sense event signal in the event that the sense amplifier does not provide a sense event signal when a contraction is identified as a function of the determined distance during a heart cycle.

15. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system having a sense amplifier, and further comprising:

operating the sense amplifier to sense electrical activity of the first heart chamber accompanying a contraction of the first heart chamber and to provide a sense event signal; and

conducting the operating step after delivery of the pacing pulse; and

decreasing the sensitivity of the sense amplifier or ignoring the sense event signal in the event that the sense amplifier provides a sense event signal but a contraction is not identified as a function of the determined distance during a heart cycle.

16. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering first and second pacing pulses separated in time by a pace delay to the first and second heart chambers, respectively, wherein the first and second heart chambers are right and left heart chambers, to elicit synchronized contractions of the first and second heart chambers;

conducting the operating step after delivery of the pacing pulse; and

adjusting the timing of delivery of the first and second pacing pulses as a function of the determined distance during a heart cycle following delivery of first and second pacing pulses to maximize the value of a weighted combination of the systolic shortening of the distance and the inverse of the end diastolic distance for a given heart rate.

17. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering a first pacing pulse to the left ventricle (LV) and a second pacing pulse to the right ventricle (RV) separated in time by a V-V pace delay to elicit synchronized contractions of the right and left ventricles;

conducting the operating step after delivery of the pacing pulse; and

adjusting the V-V pace delay as a function of the determined distance between to maximize the value of a weighted combination of the systolic shortening of the RV-LV distance and the inverse of the end diastolic distance for a given heart rate.

18. The method of Claim 1, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

delivering a first pacing pulse to the atria and a second pacing pulse to the ventricles to at least one of the right ventricle (RV) and the left ventricle (LV) separated in time by an AV delay to elicit synchronized contractions of the atria and ventricles;

conducting the operating step after delivery of the pacing pulse; and

adjusting the AV delay as a function of the determined distance to maximize the value of a weighted combination of the systolic shortening of the RV-LV distance and the inverse of the end diastolic distance for a given heart rate.

19. The method of Claim 1, wherein the implantable medical device comprises an anti-tachyarrhythmia control device for delivering a therapy in response to detection of a tachyarrhythmia of the first heart chamber, and further comprising:

following the operating step, processing the determined distance to detect a tachyarrhythmia of the first heart chamber.

20. The method of Claim 1, wherein the implantable medical device comprises an anti-tachyarrhythmia control device for delivering a therapy in response to detection of a tachyarrhythmia of the first heart chamber, and further comprising:

sensing electrical activity of the first heart chamber and provide a sense event signal;

processing sense event signals in relation to tachyarrhythmia detection criteria; and

provisionally declaring a tachyarrhythmia state of the first heart chamber when the processed sense event signals satisfy tachyarrhythmia detection criteria;

and, following the operating step:

determining the strength of contraction of the first heart chamber as a function of the distance or rate of change of the distance measured during the operating step; and

confirming the tachyarrhythmia state in the event that the strength of contraction is decreased below a predetermined value.

21. A system for monitoring patient cardiac signals and the contraction and expansion of the heart chambers during heart cycles and processing such signals within an implantable medical device (IMD) to provide data related to the mechanical performance of the heart comprising:

a magnetic field strength sensor located at a sensor site in or on a first heart chamber;

a magnetic field generator that generates a magnetic field located at a magnet site in or on a second heart chamber displaced from the sensor site at a distance that fluctuates with the contraction and expansion of the heart chambers; and

means for operating the magnetic field strength sensor during at least a portion of the heart cycle to develop a sensor output signal having a magnitude and rate of change of magnitude dependent upon the magnetic field strength of the magnetic field directly related to the distance between the magnet and sensor sites that fluctuates with the contraction and expansion of the heart chambers, whereby the output signal magnitude or rate in change of magnitude is representative of the mechanical performance of the heart chambers.

22. The system of Claim 21, wherein the sensor site is within the right ventricle and the magnet site is alongside the left ventricle.

23. The system of Claim 22, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

24. The system of Claim 23, wherein the magnetic field generator is a permanent magnet.

25. The system of Claim 21, wherein the sensor site is within the right ventricle and the magnet site is alongside the left ventricle within a coronary vein.

26. The system of Claim 25, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

27. The system of Claim 26, wherein the magnetic field generator is a permanent magnet.

28. The system of Claim 21, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

29. The system of Claim 21, wherein the magnetic field generator is a permanent magnet.

30. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering a pacing pulse to the first heart chamber to elicit a contraction of the first heart chamber; and

means for adjusting a parameter of the delivered pacing pulse as a function of the determined mechanical performance of the first heart chamber during a heart cycle following delivery of a pacing pulse.

31. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering a pacing pulse to the first heart chamber to elicit a contraction of the first heart chamber; and

means for adjusting the pacing energy of succeeding delivered pacing pulses to a pulse energy sufficient to elicit the contraction of the first heart chamber upon delivery of a pacing pulse if the magnetic field strength sensor fails to develop a sensor output signal having a magnitude or rate of change of magnitude signifying contraction of the first heart chamber in response to the delivered pacing pulse.

32. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering pacing pulses to the first heart chamber at a predetermined pacing rate to elicit contractions of the first heart chamber; and

means for adjusting the pacing rate of succeeding delivered pacing pulses to a pacing rate sufficient to elicit the contraction of the first heart chamber upon delivery of a pacing pulse if the magnetic field strength sensor fails to develop a sensor output signal having a magnitude or rate of change of magnitude signifying contraction of the first heart chamber in response to the delivered pacing pulse.

33. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for determining contractility of the first heart chamber as a function of the magnitude or rate of change of magnitude of the sensor output signal;

means for delivering pacing pulses to the first heart chamber at a predetermined pacing rate to elicit contractions of the first heart chamber; and

means for adjusting the pacing rate of succeeding delivered pacing pulses to a pacing rate that is proportional to the measured contractility sufficient to maximize the contractility of the first heart chamber upon delivery of each pacing pulse.

34. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system having a sense amplifier, and further comprising:

means for operating the sense amplifier to sense electrical activity of the first heart chamber accompanying a contraction of the first heart chamber and to provide a sense event signal; and

means for increasing the sensitivity of the sense amplifier or providing a sense event signal in the event that the sense amplifier does not provide a sense event signal when a contraction is identified as a function of the determined distance during a heart cycle.

35. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system having a sense amplifier, and further comprising:

means for operating the sense amplifier to sense electrical activity of the first heart chamber accompanying a contraction of the first heart chamber and to provide a sense event signal; and

means for decreasing the sensitivity of the sense amplifier or ignoring the sense event signal in the event that the sense amplifier provides a sense event signal but a contraction is not identified as a function of the determined distance during a heart cycle.

36. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering first and second pacing pulses separated in time by a pace delay to the first and second heart chambers, respectively, wherein the first and second heart chambers are right and left heart chambers, to elicit synchronized contractions of the first and second heart chambers; and

means for adjusting the timing of delivery of the first and second pacing pulses as a function of the determined distance during a heart cycle following delivery of first and second pacing pulses to maximize the value of a weighted combination of the systolic shortening of the distance and the inverse of the end diastolic distance for a given heart rate.

37. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering a first pacing pulse to the left ventricle (LV) and a second pacing pulse to the right ventricle (RV) separated in time by a V-V pace delay to elicit synchronized contractions of the right and left ventricles; and

means for adjusting the V-V pace delay as a function of the determined distance between to maximize the value of a weighted combination of the systolic shortening of the RV-LV distance and the inverse of the end diastolic distance for a given heart rate.

38. The system of Claim 21, wherein the implantable medical device comprises an implantable pacing system, and further comprising:

means for delivering a first pacing pulse to the atria and a second pacing pulse to the ventricles to at least one of the right ventricle (RV) and the left ventricle (LV) separated in time by an AV delay to elicit synchronized contractions of the atria and ventricles; and

means for adjusting the AV delay as a function of the determined distance to maximize the value of a weighted combination of the systolic shortening of the RV-LV distance and the inverse of the end diastolic distance for a given heart rate.

39. The system of Claim 21, wherein the implantable medical device comprises an anti-tachyarrhythmia control device for delivering a therapy in response to detection of a tachyarrhythmia of the first heart chamber, and further comprising:

means for processing the determined distance to detect a tachyarrhythmia of the first heart chamber.

40. The system of Claim 21, wherein the implantable medical device comprises an anti-tachyarrhythmia control device for delivering a therapy in response to detection of a tachyarrhythmia of the first heart chamber, and further comprising:

means for operating a sense amplifier of the implantable anti-tachyarrhythmia control device to sense electrical activity of the first heart chamber and provide a sense event signal;

means for processing sense event signals in relation to tachyarrhythmia detection criteria;

means for provisionally declaring a tachyarrhythmia state of the first heart chamber when the processed sense event signals satisfy tachyarrhythmia detection criteria;

means for determining the strength of contraction of the first heart chamber as a function of the distance measured by the operating means; and

means for confirming the tachyarrhythmia state in the event that the strength of contraction is decreased below a predetermined value.

41. In a multi-site, cardiac pacing system having memory for storing data and wherein ventricular pacing pulses are delivered to first and second ventricular sites synchronously within a V-V pace delay at a predetermined pacing rate in accordance with the steps of:

implanting ventricular pace/sense electrodes at the first and second ventricular sites;

timing a ventricular pacing escape interval;

detecting a ventricular depolarization at a selected one of the first and second ventricular sites within the pacing escape interval and, in response, terminating the pacing escape interval and providing a first ventricular sense (VS) event;

delivering a first ventricular pace (VP) pulse to the selected one of the first and second ventricular sites upon either the time-out of the pacing escape interval without provision of a first VS event or upon provision of the first VS event during time-out of the pacing escape interval;

timing the V-V pace delay from a first VS event occurring prior to the time-out of the pacing escape interval or from a first VP pulse delivered either upon provision of the first VS event or upon time-out of the pacing escape interval; and

delivering a second VP pulse to the other of the first and second ventricular sites upon the time-out of the V-V pace delay, whereby VP pulses are delivered to the first ventricular site and to the second ventricular sites at a V-V pace delay selected to enhance ventricular mechanical performance;

a method of periodically deriving trend data representative of the state of heart failure as evidenced by ventricular mechanical performance during the delivery of the VP pulses comprising the steps of:

implanting a magnetic field strength sensor at a sensor site in relation to the first ventricular site;

implanting a magnetic field generator that generates a magnetic field at a magnet site in relation to the second ventricular site and displaced from the sensor site at a distance that fluctuates with the contraction and expansion of the ventricles;

operating the magnetic field strength sensitive means during at least a portion of the heart cycle to develop a sensor output signal having a magnitude dependent upon the magnetic field strength of the magnetic field directly related to the distance between the magnet and sensor sites that fluctuates with the contraction and expansion of the ventricles, whereby the output signal magnitude is representative of the mechanical performance of the heart chambers; and

storing the sensor output signal in memory, whereby trend data representative of the state of heart failure as evidenced by changes in the stored one of the elapsed VS-VS conduction time, the VP-VS conduction time, and the VS/VP-VS conduction time between the first and second ventricular sites is accumulated for analysis of the trend.

42. A multi-site, cardiac pacing system having memory for storing data and wherein ventricular pacing pulses are delivered to first and second ventricular sites synchronously within a V-V pace delay at a predetermined pacing rate comprising:

means for implanting ventricular pace/sense electrodes at the first and second ventricular sites;

means for timing a ventricular pacing escape interval;

means for detecting a ventricular depolarization at a selected one of the first and second ventricular sites within the pacing escape interval and, in response, terminating the pacing escape interval and providing a first ventricular sense (VS) event;

means for delivering a first ventricular pace (VP) pulse to the selected one of the first and second ventricular sites upon either the time-out of the pacing escape interval without provision of a first VS event or upon provision of the first VS event during time-out of the pacing escape interval;

means for timing the V-V pace delay from a first VS event occurring prior to the time-out of the pacing escape interval or from a first VP pulse delivered either upon provision of the first VS event or upon time-out of the pacing escape interval;

means for delivering a second VP pulse to the other of the first and second ventricular sites upon the time-out of the V-V pace delay, whereby VP pulses are delivered to the first ventricular site and to the second ventricular sites at a V-V pace delay selected to enhance ventricular mechanical performance;

means for implanting a magnetic field strength sensor at a sensor site in relation to the first ventricular site;

means for implanting a magnetic field generator that generates a magnetic field at a magnet site in relation to the second ventricular site and displaced from the sensor site at a distance that fluctuates with the contraction and expansion of the ventricles; and

means for operating the magnetic field strength sensitive means during at least a portion of the heart cycle to develop a sensor output signal having a magnitude dependent upon the magnetic field strength of the magnetic field directly related to the distance between the magnet and sensor sites that fluctuates with the contraction and expansion of the ventricles, whereby the output signal magnitude is representative of the mechanical performance of the heart chambers; and

means for storing the sensor output signal in memory, whereby trend data representative of the state of heart failure as evidenced by changes in the stored one of the elapsed VS-VS conduction time, the VP-VS conduction time, and the VS/VP-VS conduction time between the first and second ventricular sites is accumulated for analysis of the trend.

43. A method for monitoring mechanical performance of a cardiovascular system comprising:

implanting a magnetic field strength sensor at a first site within the cardiovascular system;

implanting a magnetic field generator at a second site within the cardiovascular system different from the first site; and

operating the magnetic field strength sensor to provide an indication representative of mechanical performance of the heart chamber.

44. The method of Claim 43, wherein the first site is within the right ventricle and the second site is proximate to the left ventricle.

45. The method of Claim 44, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

46. The method of Claim 45, wherein the magnetic field generator is a permanent magnet.

47. The method of Claim 43, wherein the first site is within the right ventricle and the second site is within a coronary vein.

48. A method of providing electrical stimulation to a cardiovascular system of a patient, comprising:

implanting a magnetic field strength sensor at a first site within the cardiovascular system;

implanting a magnetic field generator at a second site within the cardiovascular system different from the first site;

delivering electrical stimulation to elicit a contraction of a chamber of a heart;

operating the magnetic field strength sensor to provide an indication of mechanical performance of the heart; and

adjusting delivery of additional electrical stimulation of the heart based on the indication of the mechanical performance of the heart.

49. A system for use within an implantable medical device (IMD) to monitor and/or to provide therapy to a heart, comprising:

a magnetic field strength sensor located at a first site in a cardiovascular system;

a magnetic field generator located at a second site in the cardiovascular system different from the first site, and

a circuit coupled to the magnetic field strength sensor and to the magnetic field generator to provide an indication of the mechanical performance of the heart.

50. The system of Claim 49, wherein the circuit includes means for providing an output signal having a magnitude or rate in change of magnitude that is indicative of the mechanical performance of the heart.

51. The system of Claim 49, wherein the magnetic field strength sensor is adapted to be placed at a first site within the right ventricle and wherein the magnetic field generator is adapted to be placed at a second site alongside the left ventricle.

52. The system of Claim 51, wherein the magnetic field strength sensor is a Hall effect semiconductor device.

53. The system of Claim 52, wherein the magnetic field generator is a permanent magnet.

54. The system of Claim 49, wherein the magnetic field strength sensor is adapted to be placed at a first site within the right ventricle and wherein the magnetic field generator is adapted to be placed within a coronary vein.

55. The system of Claim 49, and further comprising:

delivering means for delivering a pacing pulse to a first chamber of the heart to elicit a contraction; and

adjusting means for adjusting a parameter of the delivered pacing pulse as a function of the determined mechanical performance of the heart.

56. The system of Claim 50, and further comprising:

means for delivering a pacing pulse to a first chamber of the heart to elicit a contraction of the first heart chamber; and

means for adjusting the pacing energy of succeeding delivered pacing pulses to a pulse energy sufficient to elicit the contraction of the first heart chamber upon delivery of a pacing pulse if the output signal does not have a magnitude or rate of change of magnitude signifying contraction of the first heart chamber in response to the delivered pacing pulse.

57. The system of Claim 49, and further comprising:

means for determining contractility of a heart chamber as a function of the output signal;

means for delivering pacing pulses to the heart chamber at a predetermined pacing rate to elicit contractions of the heart chamber; and

means for adjusting the pacing rate of succeeding delivered pacing pulses to a pacing rate that is proportional to the measured contractility sufficient to maximize the contractility of the heart chamber upon delivery of each pacing pulse.